

Modeling Bowhead Whale Habitat: Integration of Ocean Models with Satellite, Biological Survey and Oceanographic Data

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Western Arctic Bowhead Whales



Photo: Hopcroft

Photo: Brenda K. Rone, NOAA/AFSC/NMML

Research Goals

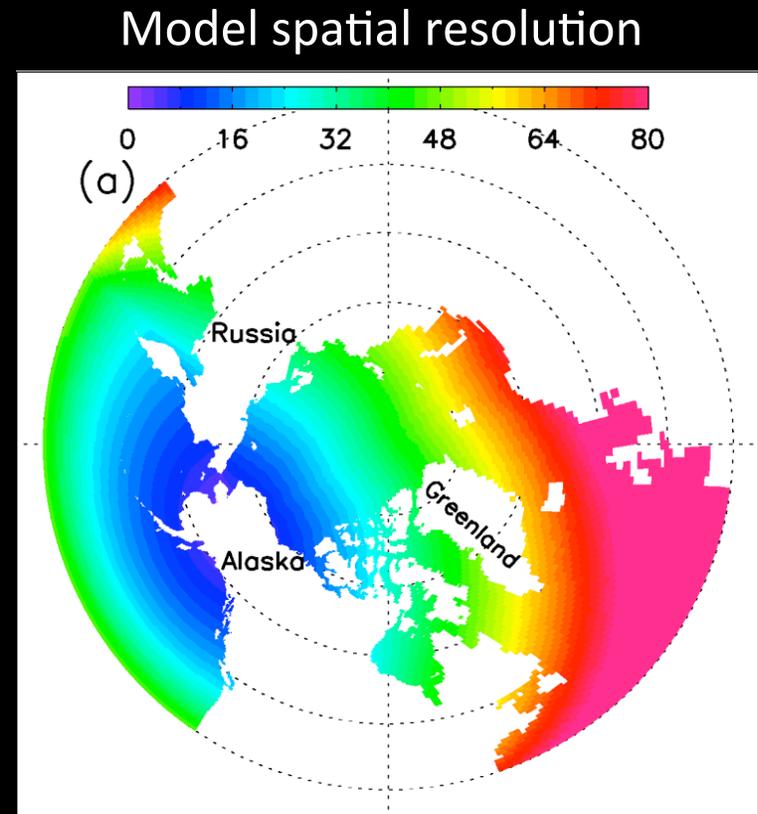
- **Map bowhead whale potential habitat suitability throughout their summer range**
 - 25 years aerial survey data
 - Arctic ocean model output
 - **Satellite data:** Pathfinder, NSIDC-0051: MODIS, SeaWiFS
 - **P-PA species distribution models**
- **Phase 1: Hindcast from 1988 – 2012**
- **Phase 2: Forecast by forcing ocean model with future climate scenarios**

Hypotheses & Questions

- Proof of concept: Can we provide reasonable representations of bowhead whale habitat?
- Is the spatial resolution of satellite and modeled data sufficient?
- Measure relative importance of biotic vs abiotic environmental variables
- Spatial & temporal model transferability:
 - yes or no
- SDM comparison:
 - MaxEnt vs BRT

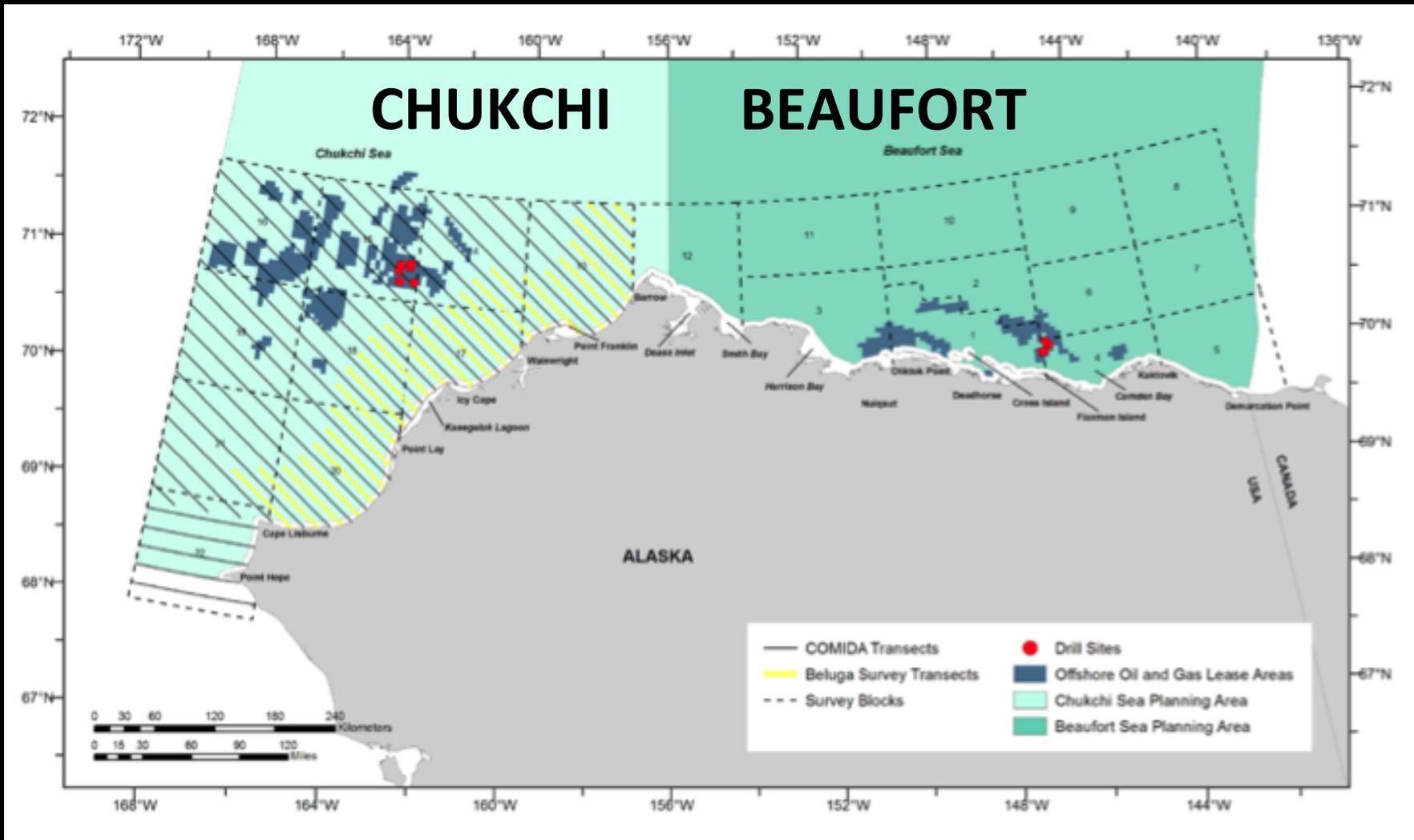
BIOMAS Arctic Ocean Model

- Biology/Ice/Ocean Modeling Assimilation System
- 3D, Pan-Arctic
- Highest resolution in Beaufort and Chukchi seas
- Hourly estimates from 1988-2013, forecast to 2050
- Estimates zooplankton concentrations
- Provides a good representation of inter-annual variability in ice, chl and temperature



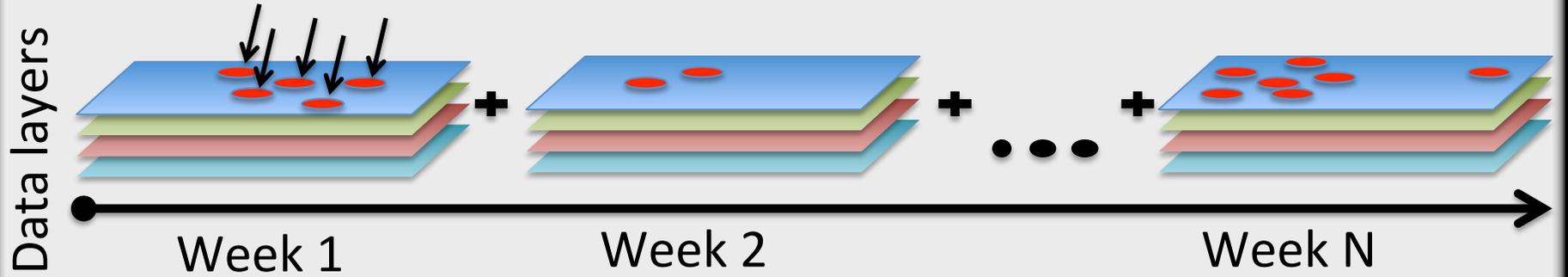
Zhang et al., 2010, JGR V 115, C10015

Study region



Clarke, J.T. et al. (2013) OCS Study BOEM 2013-0017. NMML

Bowhead whale sightings



MaxEnt & BRT

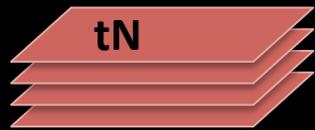
Models

Habitat Map 1

Habitat Map 2

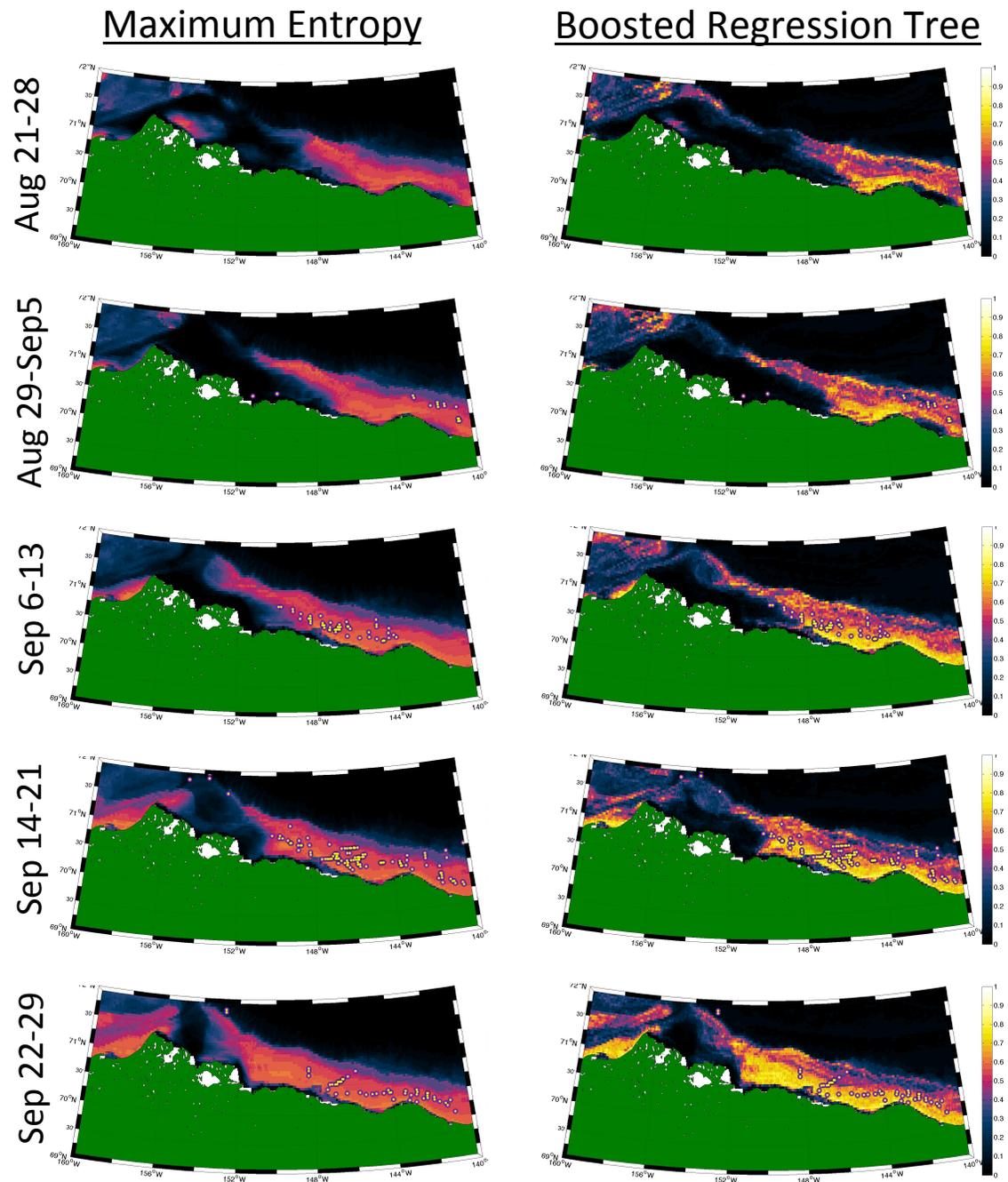
Habitat Map N

Overlay whale sightings and evaluate habitat maps

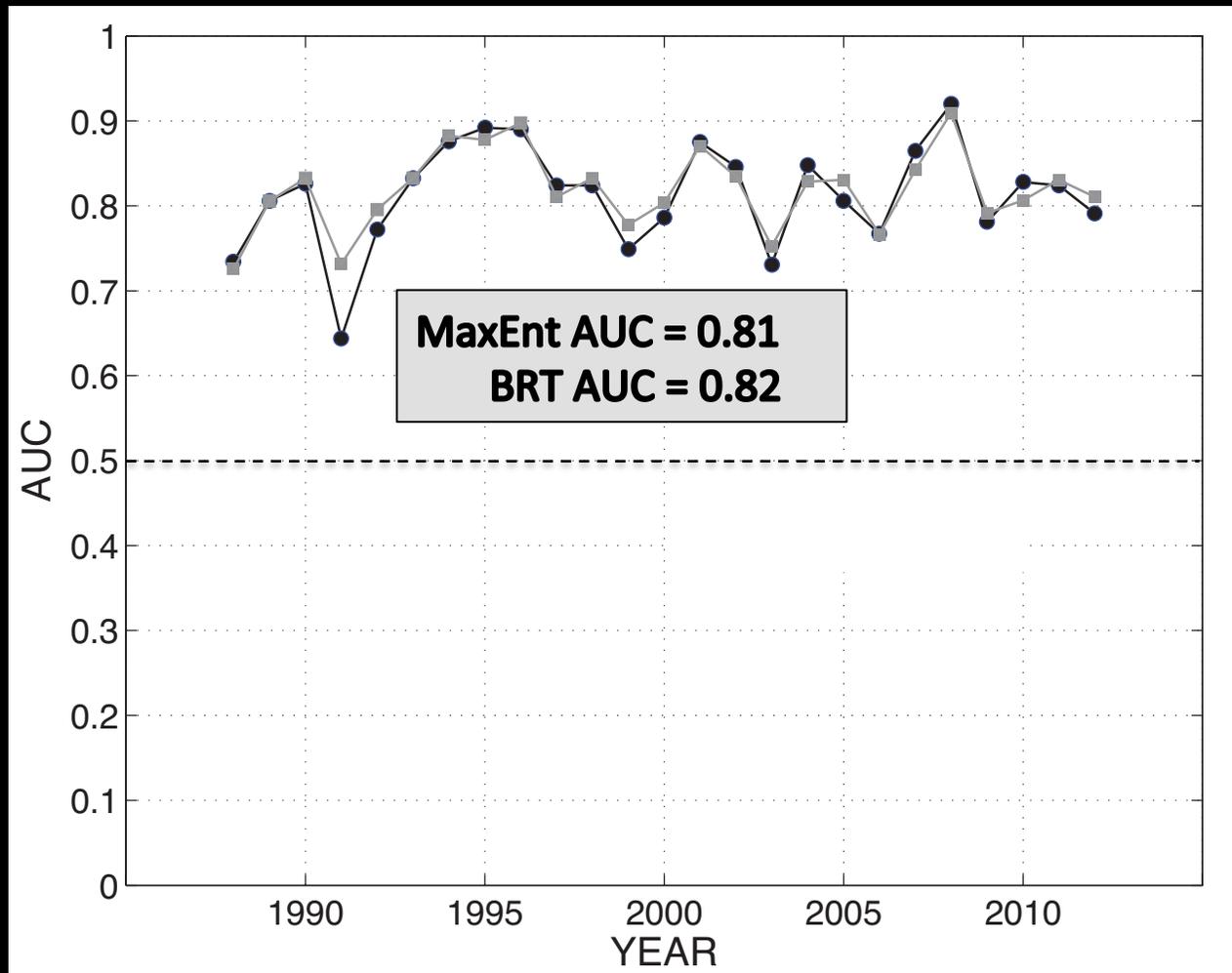


Modeled Potential Habitat with MaxEnt and BRT

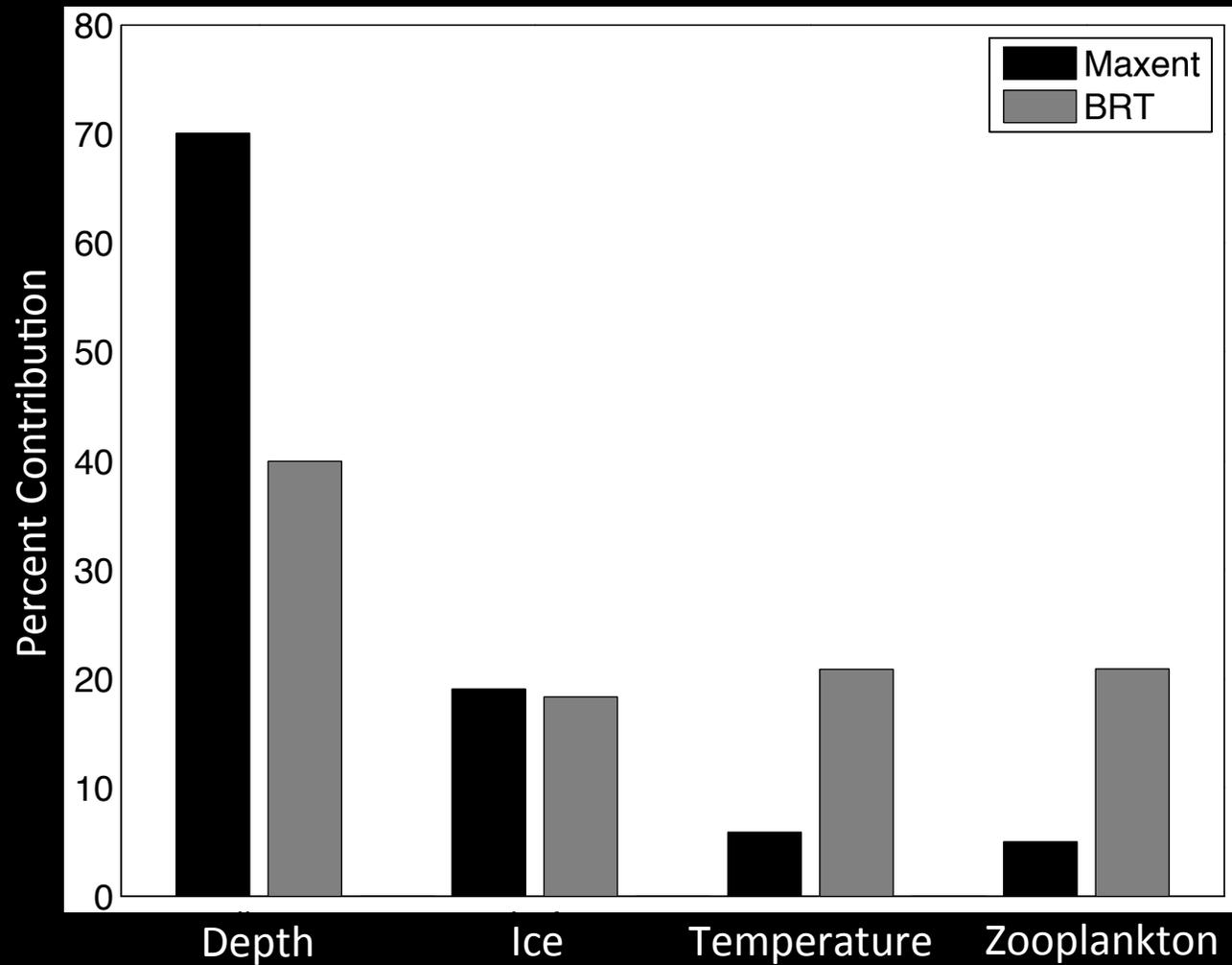
- Train with years 1988-1994 & 1996-2012
- Tested with independent data from 1995
- Based upon
 - Depth
 - Zooplankton
 - Temperature
 - Ice



MaxEnt and BRT model performance

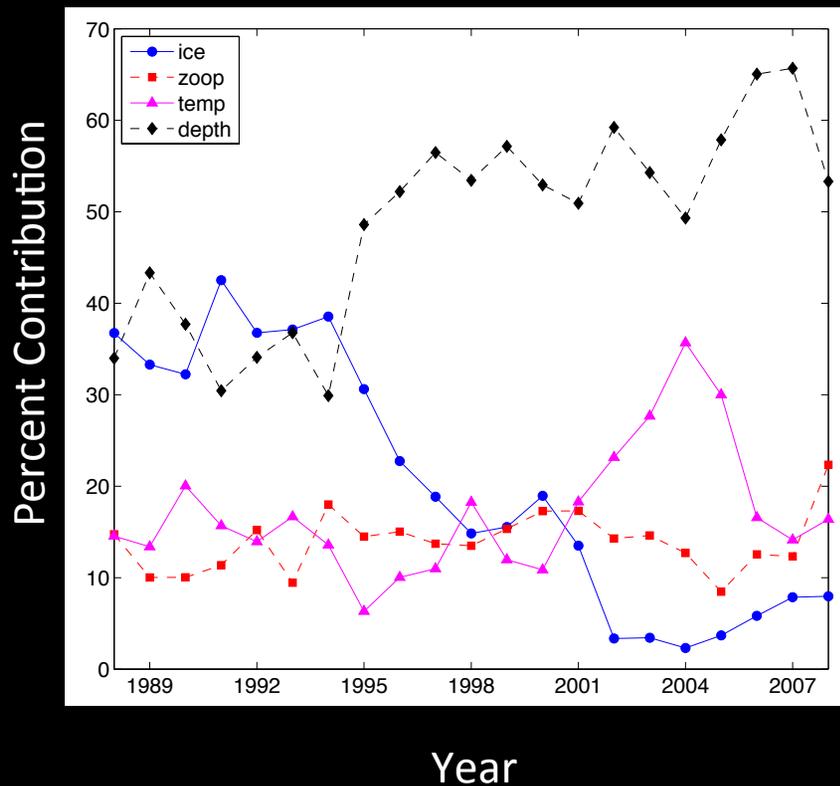


Variable Importance for models trained with all years

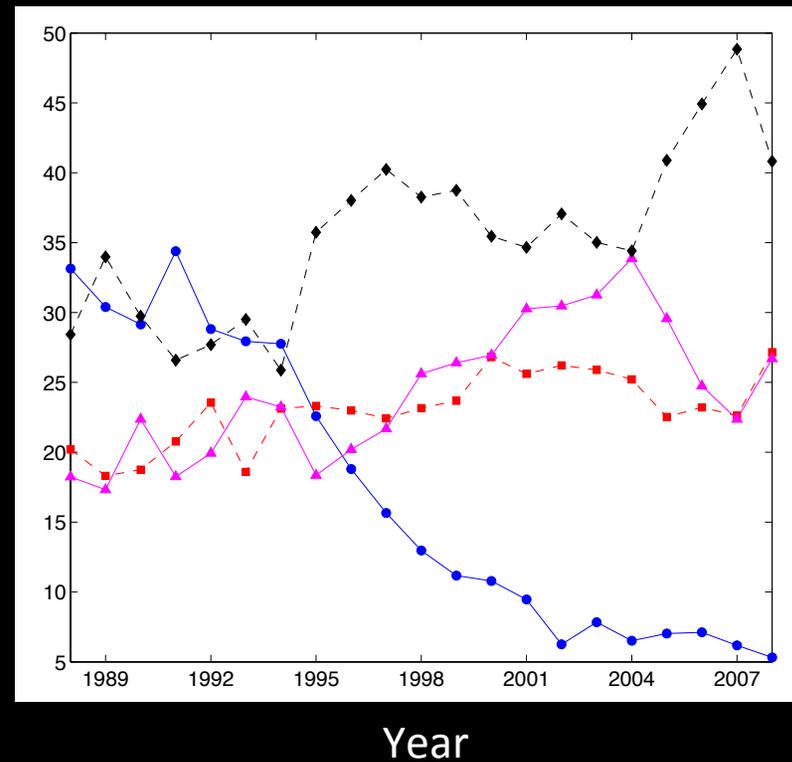


Variable importance changes

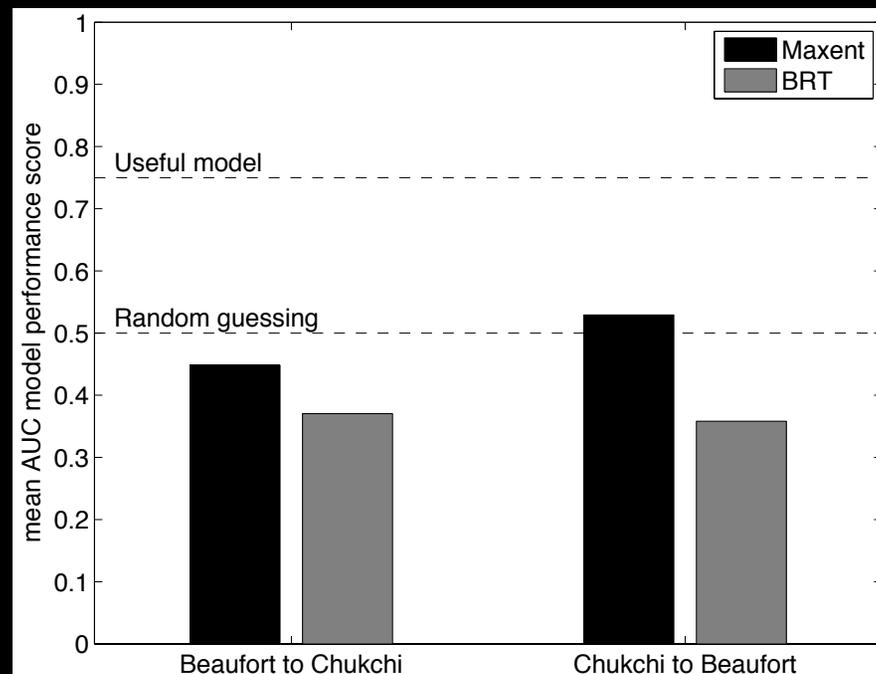
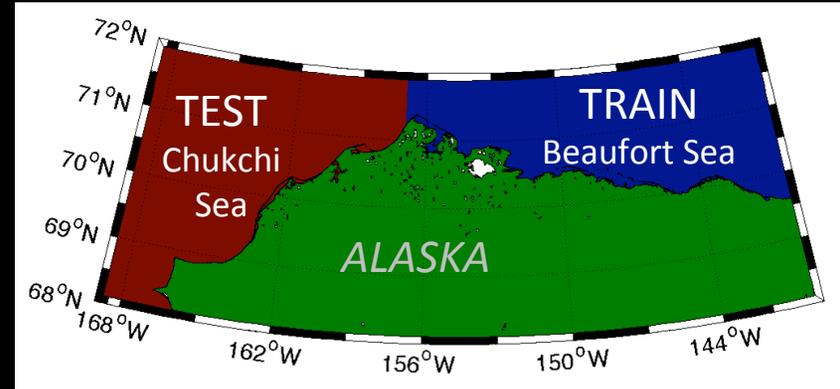
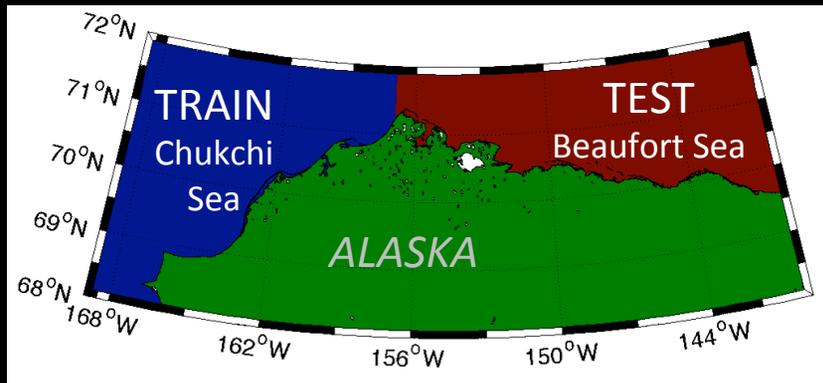
Maximum Entropy



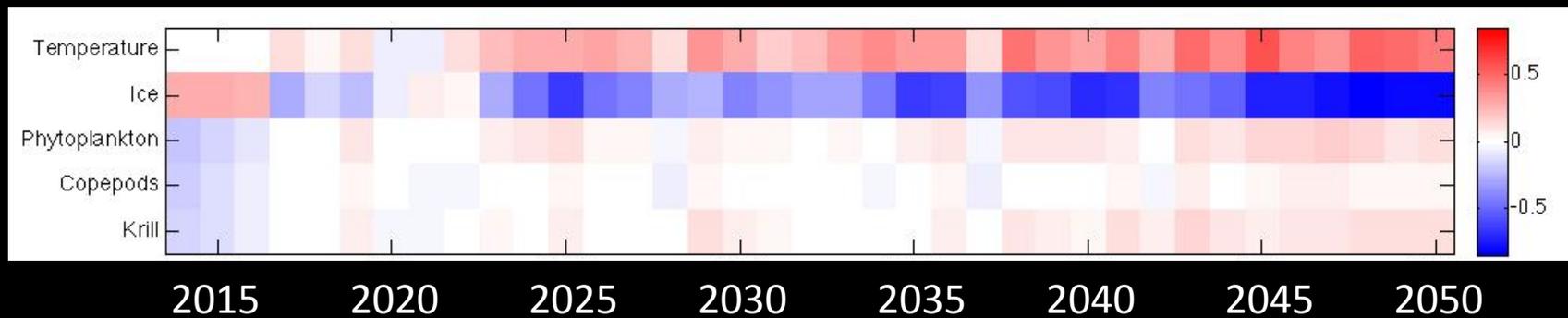
Boosted Regression Tree



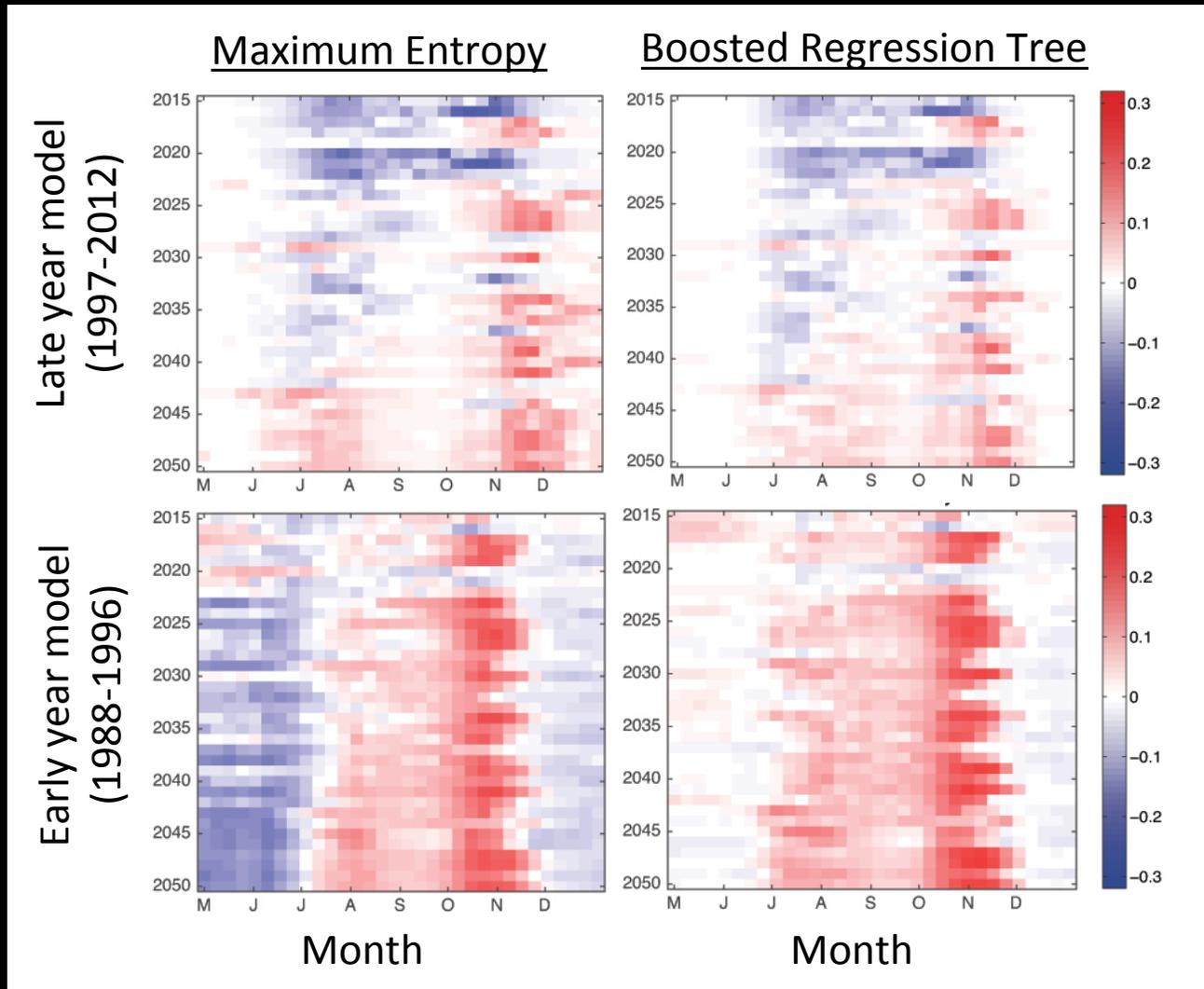
Spatial Transferability: 2008 - 2012



BIOMAS Futurecast: anomalies relative to 1988-2012



Forecasted Potential Whale Habitat Anomalies in the Beaufort Sea



Summary

- Reasonable representations of hindcasted bowhead whale habitat suitability
- Variable importance changes with time
- Models are not transferable in space
- SDM forecasts suggest that the Beaufort Sea will become a more habitable place for bowhead whales

What's left?

- Incorporate acoustic detections
- Analysis of forecasted spatial patterns
- Marine Model Mapper results outlet